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The macrozoobenthon community of the Danube between Rajka and Budapest

by

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Abstract: The ecological state of the Danube river in the impact area of the Slovakian Hydroelectric Barrage System was studied between 1987 and 1993. As a part of the hydrobiological survey of the water bodies, the macrozoobenthon community was investigated focusing mainly on the faunal description of the upper Hungarian Danube in order to collect basic ecological data. Qualitative community structure data were used for the multivariate analysis to identify characteristic sections of the river. One identical stretch of the upper Hungarian Danube is formed by four sampling sites situated in the Szigetköz area. Gradual increase of taxon number is characteristic downstream until Budapest where the richest community was detected.

Key words: macrozoobenthon fauna, community structure, multivariate analysis

Introduction

The investigated upper stretch of the Hungarian Danube impacted by the Slovakian water barrage system has two different major sections. The Szigetköz flood-plain just after the Hungarian border contains numerous different types of water bodies including the main river arm (50 km) itself. The following Danube River (140 km) has rather uniform large river channel along its whole length with a faster section passing the Visegrád Mountains (Danube Bend) at 60 km upstream of Budapest.

The first 50 km section of the main river arm is characterized by strong current and high water velocities, due to larger bed-slope values (20-50 cm/km). An extended side-arm system, developed by river regulating activity, follows the main Danube forming the active flood plain. The side-arms receive direct surface inflow from the Danube only above 2300 m^3/sec due to the upstream inlets, having stabilized level by rock fill dams. The hydrogeological history of the area and the development of dead arms, old meanders, marshlands, more or less stagnant water bodies due to river engineering is discussed by Göcsei (1979) in details. Channels for irrigation and drainage and gravel mine lakes are isolated by flood protecting embankments from the active flood plain. Their actual water-level and groundwater supply is determined by the hydrological situation.

The sharp decrease of the slope after Gönyü results in slower current velocities. In a natural river-bed where dredging and bank protection works take place nowadays, regulation and stabilization of the original channel was carried out during the last century.

Series of hydrobiological studies has been started at the Water Resources Research Centre (VITUKI) in 1981 concerning phytoplankton, zooplankton and macrozoobenthon communities, to a limited extent fish faunal survey has also been carried out. The basic purpose of the research was to predict the ecological impact of the barrage system. Therefore, knowledge of the original hydrobiological state of the Danubian water bodies using floral and faunal data before the operation of the barrage system was essentially important. The research was accelerated at the end of the 80's resulting in numerous synbiological results.

A great amount of data are available about the seasonal chemical water quality of the Danube between Rajka and Budapest measured by the local Water Quality Laboratories (Varga *et al.* 1989, László & Varga 1990) indicating the pollution effect of the Sewage Treatment Works of Győr arriving from the Mosoni Danube (Várday 1987, Várday & T. Bartalis 1991). The trophic and the saprobic state of the river was also investigated (T. Bartalis 1974, 1978). The continuous increase of the phytoplankton biomass and the organic load were identified since the end of the 70's (T. Bartalis 1987, 1991), pointing out the possible increasing trophity effect of the Austrian reservoirs due to storage (Kiss 1987).

Several phytoplankton studies, carried out on the upper stretch of the Hungarian Danube including the water bodies of the Szigetköz floodplain, were dealing with algal floristics (Kiss 1987, T. Bartalis 1987, 1991) and community structure (Németh 1989). The spatial heterogeneity of the chlorophyll-a content proportional to the phytoplankton biomass was studied in the Ásványi side-arm (Németh & Skobrák 1985) together with the photosynthetic oxygen production (Csányi *et al.* 1985).

The changing connection between the side-arms and the main river channel in terms of dissolved oxygen budget was measured in order to evaluate the effect of the side-arm system on the natural purification processes in the Danube (T. Dvihally 1987). Studies on the Ciliata fauna (Cs. Bereczky 1987) and the zooplankton (Gulyás 1989, 1991) were used to characterize the seasonal saprobiological state of the upper stretch of the Hungarian Danube and the side-arm system in different hydrological conditions.

The taxon list of potamal molluscs living in the Hungarian Danube contains several aquatic snail and mussel species from the upper stretch having special zoogeographical importance (Bothár 1966, Richnovszky 1970, 1979). However, data on the faunal distribution of molluscs were very seldom. The leech fauna of the Danube and the adjacent region is discussed by Puky (1989). Special notes concerning distribution of benthic taxa along the Danubian river system and differences between neighbouring watersheds due to hydrogeological history are analyzed (Nesemann 1992, Nesemann & Csányi 1993). Predicted ecological effects of the Nagymaros-Bős water barrage system on the ichthyofauna and the benthic community caused by peak power generation technology are summarized by Holcik *et al.* (1981).

Survey of the Szigetköz region describing the community structure of phytoplankton, zooplankton and macrozoobenthon by multivariate methods resulted in a classification of different water bodies (Csányi 1989, Németh 1989, Gulyás *et al.* 1991). The importance of the Szigetköz in the natural reproduction of fish stock in the process of recolonization of the Danube river downstream was well known (Tóth 1960). The estimated decrease of the fish stock and the average fish catch in the Szigetköz and the River Danube as an essential impact of the barrage system are presented by Jancsó & Tóth (1987).

Due to spatial limitations, this paper deals only with the main Danube stretch. Detailed faunal results of the macroscopic invertebrate community (macrozoobenthon) are given as an attempt for the longitudinal classification of the river.

Material and methods

Sampling sites between Rajka and Budapest (1850 and 1659 river km) are shown in Fig. 1. Capitals MK and MD at a given location are referring to the macroscopic invertebrate (macrozoobenthon) littoral kick samples and profundal dredge samples, respectively.

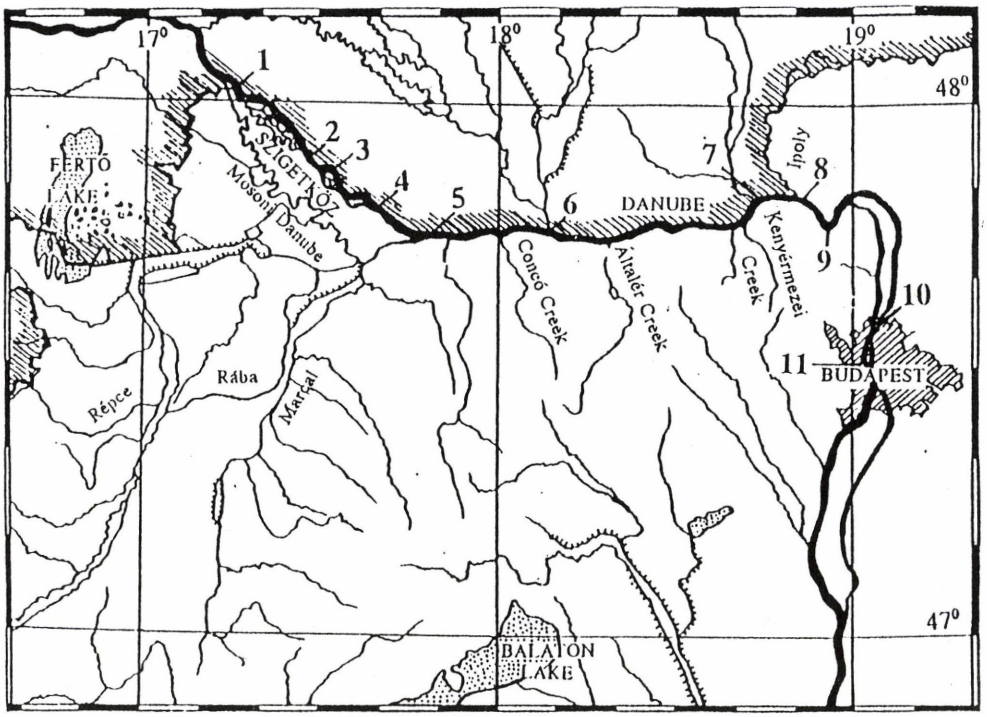

Fig. 1. Map of the sampling sites on the Danube between Rajka and Budapest. Legend: 1. Rajka (M_K, M_D); 2. Dunaremete (M_K, M_D); 3. Ásványráró (M_K); 4. Medve (M_K, M_D); 5. Gönyü (M_K, M_D); 6. Komárom (M_K, M_D); 7. Esztergom (M_K, M_D); 8. Szob (M_K); 9. Visegrád (M_D); 10. Budapest, Drinking Water Works (M_K, M_D); 11. Budapest, Batthyányi Square (M_D)

Longitudinal sampling program was started in 1987 and was completed during the last five years at low water flow periods in order to reveal the invertebrate community of the Danube. Kick samples from the shore line were collected at 9 sites using the standard British FBA pond net with a mesh size of 950 m (Furse et al. 1984). An approximately 20 kg dredge sampler was applied successfully for sampling the middle deep parts of the Danube bed with motorboat.

Qualitative benthon data were analyzed by multivariate classification and ordination methods using the SYN-TAX 5.0 program package (Podani 1993).

Cummulated results of data collected by kicking between 1987 and 1993 and by dredging in 1991 are presented in order to illustrate the species distribution along the Danube. The most important faunal results are discussed in details with special emphasis on recent ecological changes as a result of the Slovakian diversion of the original river flow.

Table 1. Macrozoobenthon taxa found in kick samples of the littoral (1987-1993) (for explanation of numbers of sampling sites see Fig. 1)

No.	Taxa	Sampling sites									
		1	2	3	4	5	6	7	8	9	Total
	Tricladidae										
1	*Dendrocoelum lacteum* O.F.M.	0	1	0	0	0	1	1	0	1	4
2	*Dugesia* sp.	0	1	0	1	0	0	0	0	1	3
	Mollusca										
3	*Ancylus fluviatilis* O.F.M.	1	1	1	1	1	1	0	0	1	7
4	*Anodonta anatina* L.	1	0	1	0	0	0	1	1	0	4
5	*Bithynia tentaculata* L.	1	1	0	0	1	1	1	1	1	7
6	*Dreissena polymorpha* Pallas	1	1	1	1	1	1	1	1	1	9
7	*Esperiana esperi* Férussac	0	0	0	0	0	0	1	1	1	3
8	*Lithoglyphus naticoides* C.Pfeff.	1	0	1	1	1	1	1	1	1	8
9	*Microcolpia acicularis* Férussac	0	0	0	0	0	0	0	1	1	2
10	*Pisidium amnicum* O.F.M.	0	0	0	0	1	0	0	0	1	2
11	*Pisidium* sp.	0	1	1	1	1	0	1	1	1	7
12	*Potamopyrgus antipodarum* Gray	0	0	1	0	0	0	0	0	1	2
13	*Pseudanodonta complanata* Rossm	0	0	0	0	0	0	0	1	0	1
14	*Radix auricularia* L.	1	1	1	0	0	1	1	0	0	5
15	*Radix ovata* Draparnaud	1	1	1	1	1	1	0	1	1	8
16	*Radix peregra* O.F.M.	0	0	0	0	0	0	0	0	1	1
17	*Sphaerium corneum* L.	1	1	1	1	0	1	1	1	1	8
18	*Theodoxus danubialis* C.Pfeiff.	0	0	0	0	1	1	1	1	1	5
19	*Theodoxus fluviatilis* L.	1	0	0	0	1	0	0	0	1	3
20	*Unio crassus* Philippson	0	0	0	0	1	0	0	0	1	2
21	*Unio pictorum* L.	1	0	0	0	0	0	0	0	1	2
22	*Valvata piscinalis* O.F.M.	0	0	0	0	0	0	0	1	1	2
23	*Viviparus acerosus* Bourguignat	0	0	0	0	0	1	1	1	1	4
	Annelida										
24	*Dina* sp.	1	1	1	1	1	0	1	1	1	8
25	*Erpobdella octoculata* L.	1	1	1	1	1	1	1	1	1	9
26	*Glossiphonia complanaata* L.	0	0	0	0	1	0	1	1	1	4
27	*Glossiphonia paludosa* Carena	0	0	0	0	1	0	0	0	0	1
28	*Hypania invalida* Grb.	0	1	1	0	1	1	0	1	1	6
29	*Oligochaeta* sp.	1	1	1	1	1	1	1	1	1	9
30	*Piscicola geometra* L.	0	0	1	1	0	0	0	1	1	4
	Crustacea (Malacostraca)										
31	*Corophium curvispinum* Sars	1	1	1	1	1	1	1	1	1	9
32	*Dikerogammarus villosus* Sovinski	1	1	1	1	1	1	1	1	1	9
33	*Jaera istri* Vieulle	1	1	1	1	1	1	0	1	1	8
34	*Limnomysis benedeni* Czerniavsky	0	0	0	0	0	1	0	1	0	2
35	*Obesogammarus obesus* Sars	0	0	0	0	0	1	0	1	1	3
	Insecta										
36	*Ablabesmyia* sp.	1	0	0	0	0	0	0	0	0	1
37	*Aphelocheirus aestivalis* Fabr.	0	0	1	0	1	0	0	0	0	2
38	*Baetida* sp.	0	0	0	1	0	0	0	0	0	1
39	*Brachycentrus* sp.	0	1	0	1	1	0	0	1	1	5
40	*Chironomida* sp.	1	1	1	1	1	1	1	1	1	9
41	*Clinotanypus* sp.	1	0	0	0	0	0	0	0	0	1
42	*Cricotopus* sp.	1	1	1	1	1	1	0	1	1	8
43	*Heptagenia* sp.	1	0	0	0	0	0	0	0	0	1
44	*Heptagenia sulphurea* Müller	1	1	1	1	1	1	0	1	1	8
45	*Hydropsyche contubernalis* McL.	1	1	1	1	1	1	1	1	1	9
46	*Hydropsyche pellucidula* Curtis	1	1	0	1	1	0	0	1	1	6
47	*Limoniida* sp.	0	0	0	1	0	0	0	0	0	1
48	*Polypedilum* sp.	0	0	0	0	0	0	0	1	0	1
Total number of taxa		24	22	22	22	26	22	18	29	36	221

Results

Results of the faunal survey

The total number of benthic taxa in the kick samples was relatively high everywhere (Fig. 2), but it increased to its maximum in the section just upstream of Budapest (36 taxa just at the Surface Drinking Water Works).

The cummulated taxon list contains 48 benthic taxa collected by kick sampling from the littoral zone of the Danube (Table 1). Altogether 2 flatworm, 21 mollusc, 7 annelid, 5 crustacean and 14 insect taxa were found in the shallow, permanently inundated region of the river. Almost half of the taxa (22) were found at 5 or more sampling sites during the research period, indicating the relatively high number of common taxa.

Numerous new faunal data were gained during the last few years, some species were never detected in this river section. The aquatic neritid snail *Theodoxus fluviatilis* was known only in few locations of the Tisza river sofar. A considerable population was discovered in 1987, living just above Budapest. The species is distributed along the whole Budapest stretch of the river according to the detailed survey carried out in 1990. New localities were revealed in the next years in Gönyü (1991), in Rajka (1992), by dredging in the middle of the river bed.

All of these data suggest that considerable isolation exists between the populations within one river system. Similar results concerning other species of the same genus (*Th. transversalis* in the Tisza river system) were gained during the last few years, but the reason of the disjunct occurences are still unknown. The characteristic Danubian snail, *Theodoxus danubialis* is found only in the lower half of the sampled river section, although this species is present at many sites in the Mosoni Danube, situated in the Szigetköz flood plain (Nesemann 1992).

The data on the occurrence of the *Potamopyrgus antipodarum* in the Danube are also new. Two thiarid species, *Esperiana esperi* and *Microcolpia acicularis* are found only in the lower

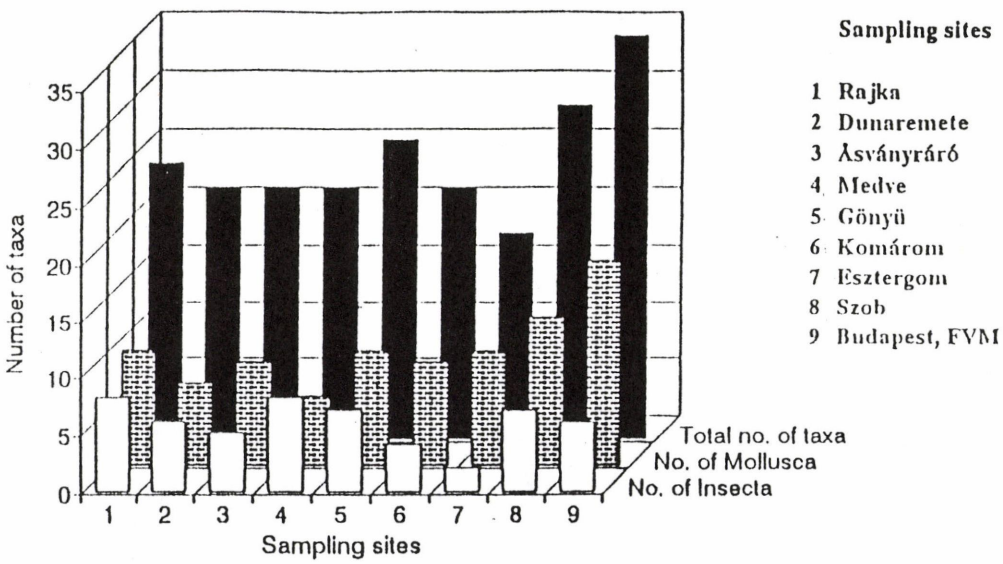

Fig. 2. Macrozoobenthon taxa along the Danube River (cummulated results of kick samples collected in 1987-1993)

range of the investigated area. These taxa live in the Mosoni Danube too, but are absent from the upper main Danube arm. *Hypania invalida*, the only pontocaspic polychaet worm of Hungary, is relatively common between Rajka and Budapest. New records of the aquatic bug, *Aphelocheirus aestivalis*, are given in this report from the upper stretch (Ásványráró and Gönyü) having characteristic rapid currents.

Although the number of benthic taxa, living in the profundal region of the Danube, is much

Table 2. Macrozoobenthon taxa found in dredge samples of the profundal (1987-1993) (for explanation of numbers of sampling sites see Fig. 1)

No.	Taxa	Sampling sites									
	Cnidaria	1	2	3	4	5	6	7	8	9	Total
1	*Hydra* sp.	0	0	0	0	0	0	0	0	1	1
	Mollusca										
2	*Dreissena polymorpha* Pallas	0	0	0	0	0	0	0	1	0	1
3	*Esperiana esperi* Férussac	0	0	0	0	0	0	0	0	1	1
4	*Pisidium* sp.	0	0	0	0	0	0	1	0	1	2
5	*Potamopyrgus antipodarum* Gray	0	0	0	0	0	0	0	0	1	1
6	*Sphaerium corneum* L.	0	0	1	0	0	0	0	0	1	2
7	*Theodoxus fluviatilis* L.	0	0	0	0	0	0	0	1	1	2
8	*Viviparus acerosus* Bourguignat	0	0	0	0	0	0	0	0	1	1
	Annelida										
9	*Aelosoma* sp.	0	0	0	0	0	0	0	0	1	1
10	*Criodrilus lacuum* Hoffmeister	0	0	0	0	0	0	0	1	0	1
11	*Oligochaeta* sp.	0	1	1	1	1	0	0	0	1	5
	Crustacea (Malacostraca)										
11	*Corophium curvispinum* Sars	1	1	0	0	0	0	0	0	0	2
12	*Dikerogammarus villosus* Sovinski	1	1	0	1	1	1	1	1	1	8
13	*Limnomysis benedeni* Czerniavsky	0	0	0	0	0	0	0	1	0	1
14	*Obesogammarus obesus* Sars	0	0	0	0	0	0	1	0	0	1
	Insecta										
15	*Cricotopus* sp.	1	1	0	1	1	1	1	1	1	8
16	*Heptagenia sulphurea* Müller	0	0	0	0	0	0	1	0	0	1
17	*Hydropsyche angustipennis* Curtis	0	0	0	0	0	0	0	1	1	2
18	*Hydropsyche contubernalis* McL.	1	1	0	1	1	0	1	0	1	6
19	*Hydropsyche* sp.	0	0	0	0	0	0	0	0	1	1
Total number of taxa		4	5	2	4	4	2	6	7	14	48

lower than in the littoral zone, the richness of the community has considerably increased downstream (Table 2). 14 taxa were found in the lowest cross section at Budapest, many of them are absent from the upstream stretch. The most common taxa are the amphipod *Dikerogammarus villosus*, the chironomid *Cricotopus* sp., *Hydropsyche contubernalis* and the *Oligochaeta* sp. Only two common mollusc taxa (*Pisidium* sp., *Sphaerium corneum*) were present in the dredge samples above Budapest, but 6 were detected at the last two sampling sites of the city. The three snail species (*Esperiana esperi*, *Potamopyrgus antipodarum, Theodoxus fluviatilis*) living in the main current were not described from the profundal region earlier. Further investigations, with special dredging methodology in the zones near the littoral will most probably provide numerous new data on the distribution of many benthic taxa.

Classification and ordination of the kick and dredge samples

The hierarchical classification (cluster analysis) of both data-groups, resulted in highly similar dendrograms. Different similarity functions were used. The upper Hungarian river stretch (sampling sites 1-4 in the Szigetköz) formed one subgroup (Figs 3 and 4), connected to the other sites in a chain-like structure. The so called "chain effect" (i.e. the addition of the new sampling sites to the previous group, without forming any new sub-group) suggests a continuous change in the macrozoobenthic fauna along the Danube, where new species occur in the community (increasing taxon number).

The sampling sites and the corresponding taxa are illustrated on rotating plots. The common taxa occuring at many sampling sites are responsible for the central position of those sites (Fig.

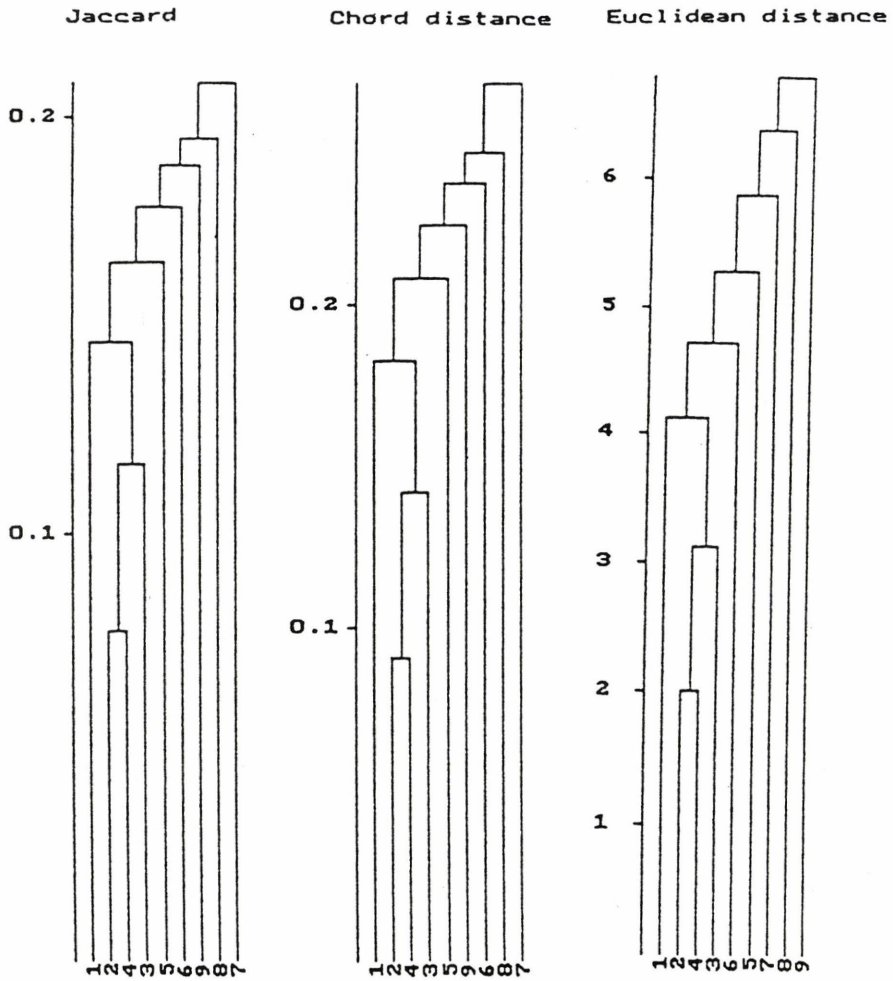

Fig. 3. Dendrograms of sampling sites of the Danube based on macrozoobenthon taxa collected by kick sampling

4). On the other hand, rare species result in the marginal appearence of the given sites (i.e. site 1 at Rajka has three unique overlapping taxa).

The water level had important influence on sampling efficiency. Sampling during long term low water-level resulted in collection of many species. In this case the littoral zone contains always a more rich benthic community compared to the middle river bed. The poor macrozoobenthon community of the deep, middle part of the river is probably caused by the strong current conditions.

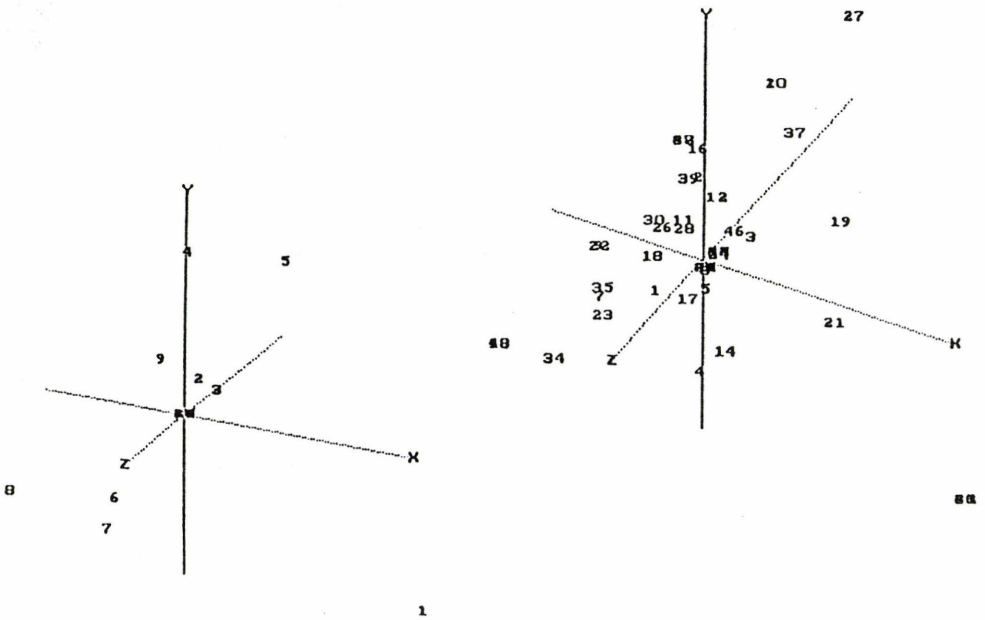

Fig. 4. Ordination plots of sampling sites (1-9) and taxa (1-48) (Correspondence analysis)

Table 2 illustrates the 20 taxa collected by dredge sampler from the deep region of the river-bed. Although the number of taxa is less than the half of the littoral fauna, similar picture is recognizable in the sequence of sampling sites based on the results of the cluster analysis (Fig. 5). Site 3 (Medve) with the very poor fauna appears as an outlier according to three similarity functions of the four. Sampling sites from the upper section have the more similar character to each other. One definite group is recognizable on the ordination plot received by correspondence analysis. Rajka, Dunaremete, the overlapping Gönyü and Komárom together with Esztergom are in central position. The sites of Visegrád (No. 7) and the two Budapest sections (Nos 8, 9) have increasing taxon numbers, most probably because of the decreasing velocity of the water current.

According to the multivariate analysis based on kick and dredge sample data of the benthic community the upper Hungarian Danube has one identical stretch that is corresponding more or less to the Szigetköz region. According to the analysis, to the downstream sites gradual transition is experienced with increasing number of taxa, most probably due to moderate changing of current conditions along the river.

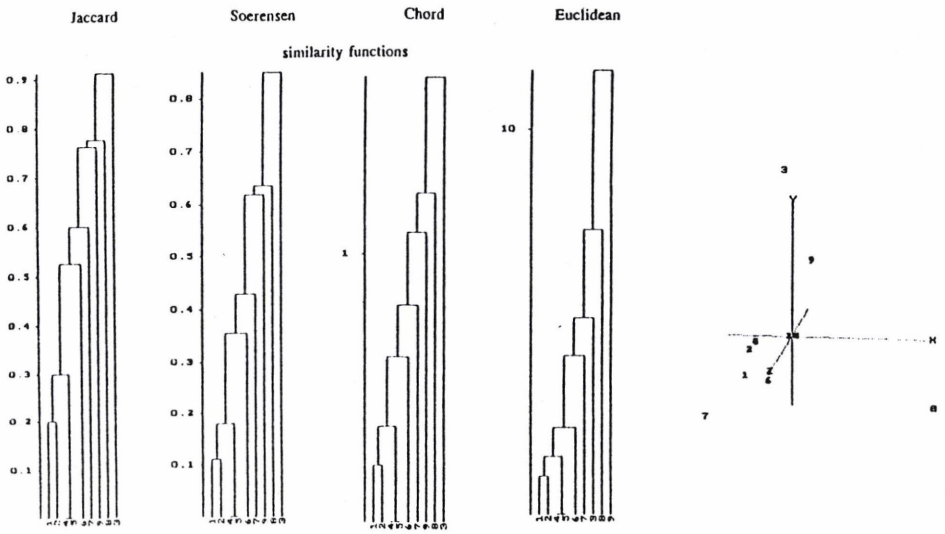

Fig. 4. Ordination plots of sampling sites (1-9) and taxa (1-48) (Correspondence analysis)

The effect of the Slovakian water diversion on the benthic fauna

The operation of the Slovakian Barrage System started on October 25, 1992 with the final diversion of the main water flow of the Danube to the channel of the hydroelectric power plant. Several macrozoobenthon samplings have been taking place since the October 26 until now, in order to describe the changes of the coexistential pattern of the community due to the impact.

Obviously, the most considerable decrease of the water level developed just below the diverting cross dam. Due to the drastic decrease of the present flow (200-250 m^3/sec), the water level stabilized more than 2.5 m lower, than the ever measured lowest at low flow (approx. 1000 m^3/sec) conditions.

An extended littoral area became dry and resulted in the immediate death of the aquatic macrofauna. Huge amount of *Sphaerium corneum, Dikerogammarus villosus, Corophium curvispinum*, leeches, insects and other species (even specimens of fish taxa like *Cottus gobio* and *Proterorhynchus marmoratus*) were found dead just in the Rajka stretch on the day following the diversion. Instead of several meters of water level change, only few centimeters are occuring as a result of the highly regulated water discharge. Consequently, many species are found now just below the water air interface because the lack of the level fluctuation (i.e. *Ancylus fluviatilis, Hydropsyche* taxa).

Virtually, there are the same species living in the remaining river bed as earlier, but the flooded area and the water-flow decreased considerably. The most harmful impacts are apparent in the formerly active side-arm system of the Szigetköz flood-plain. Long sections of side-arms became completely dry. This time only the deepest channels contain stagnant water bodies but they are isolated from each other. The earlier common high flood conditions (water flow even above 10000 m^3/sec) have completely disappeared. The whole hydrological cycle has dramatically changed because of the diversion of the main Danube flow to the barrage system. The considerable damage of the aquatic flora and fauna is characteristic in many places. The

detailed analysis of the impact on the flood plain is not the object of the present paper because only the problems of the main river are discussed here. Although, the problems of the flood protected area with high diversity of different former water bodies (old meanders, oxbows, marshlands, swamps, dead arms etc.) have to be mentioned.

Conclusions

The macroscopic invertebrate community of the upper Hungarian Danube was investigated during the last 6 years in order to reveal the faunal distribution of taxa along the river. Two different sampling methods (kicking and dredging) resulted in similar conclusions. The number of taxa is gradually increasing downstream to Budapest. On the bases of multivariate analysis, one identical section situated along the Szigetköz section of the river containing four sampling sites has very similar macrozoobenthon community, most probably due to similar, fast flowing conditions. Several data referring to the Danubian macrozoobenthon fauna are new, especially the results of the dredge samples from the profundal region of the river.

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